Description

COIL FORMING INSERTION DEVICE AND COIL FORMING INSERTION METHOD

Technical Field

The present invention relates to a coil forming insertion device and a coil forming insertion method for forming a coil used in a motor (electric motor), etc., and inserting and arranging this coil in a stator core.

Background Art

For example, in the manufacture of a motor having a stator constructed by inserting plural monopole coils into a slot of the stator core, a joining pole coil constructed by joining a plurality of the above monopole coils is formed.

In a conventional coil forming method, a winder for guiding an electric wire (wire) while winding around a fixed winding frame is used, and the electric wire is wound around this winding frame and the monopole coil is formed. For example, in Patent literature 1, the outside diameter of the winding frame for winding the electric wire can be changed. A flyer as the above winder is rotated around this winding frame. The joining pole coil used in the above motor is formed by sequentially wind-dropping the wound monopole coil to a blade.

"Patent literature 1": JP-A-2000-253631

However, in the above Patent literature 1, when the monopole coil after the above winding operation wind-drops to the above blade, the monopole coil drops to the clearance between needles of the above blade from the above winding frame. Therefore, in a certain case, there is a fear that no monopole coil can drop to the above clearance. Accordingly, it is not sufficient to reliably move and mount the monopole coil. Further, in a certain case, when the monopole coil drops to the blade, there is a fear that the winding order of each electric wire in this monopole coil is different from the winding order in which the above winding operation is performed.

Further, in the Patent literature 1, after one monopole coil is formed in one winding frame, this monopole coil sequentially wind-drops to the blade. Therefore, there is a fear that the length of a connecting wire for connecting the respective monopole coils to each other is dispersed. Further, the joining pole coil having the respective monopole coils joined by the connecting wire is formed on the blade. Accordingly, there is a fear that no forming state of the formed joining pole coil is stabilized.

Disclosure of the Invention

The invention is made in consideration of such conventional problem points, and provides a coil forming insertion device and a coil forming insertion method able to

stabilize the length of the connecting wire for connecting the respective monopole coils to each other, and able to move and mount the joining pole coil by approximately simultaneously and reliably delivering each monopole coil to each coil receiving portion without almost changing the forming state of the joining pole coil.

A first aspect of the invention resides in a coil forming insertion device comprising a winding jig for forming a joining pole coil constructed by joining plural monopole coils each formed by winding an electric wire in a loop shape, and an inserter jig opposed to the winding jig and receiving the joining pole coil and inserting and arranging the joining pole coil in a slot formed on the inner circumferential face of a stator core;

wherein the winding jig has plural coil winding frames, and the inserter jig has plural coil receiving portions for respectively receiving each monopole coil from each coil winding frame; and

each coil receiving portion is opposed to each coil winding frame, and the joining pole coil formed by joining each monopole coil wound around each coil winding frame is constructed so as to be moved and mounted from the winding jig to the inserter jig.

In the coil forming insertion device of the invention, the joining pole coil is formed in the above winding jig and each monopole coil is approximately simultaneously delivered

to each coil receiving portion and can be moved and mounted to the inserter jig as the joining pole coil.

Namely, the above winding jig is constructed by arranging the plural coil winding frames, and the joining pole coil can be formed by forming the monopole coil in each coil winding frame in this winding jig. Therefore, each monopole coil can be formed in each coil winding frame in which the mutual position relation is fixed. Accordingly, it is possible to stabilize the length of a connecting wire formed between the respective monopole coils wound around the respective coil winding frames.

Further, the above inserter jig has the plural coil receiving portions. When each coil winding frame for holding the monopole coil and each coil receiving portion are opposed to each other, each monopole coil can be approximately simultaneously and reliably delivered to each coil receiving portion. Therefore, in this delivery, there is almost no case in which the winding order of each electric wire in each monopole coil is different from the winding order in which the above winding operation is performed.

Therefore, this joining pole coil can be moved and mounted from the winding jig to the inserter jig without almost changing the forming state of the joining pole coil.

A second aspect of the invention resides in a coil forming insertion device comprising a winding jig for forming a joining pole coil constructed by joining plural monopole coils each

formed by winding an electric wire in a loop shape, and an inserter jig opposed to the winding jig and receiving the joining pole coil and inserting and arranging the joining pole coil in a slot formed on the inner circumferential face of a stator core;

wherein the winding jig is constructed by arranging plural coil winding frames for forming the monopole coil by winding the electric wire at about the same distance from the central point of the winding jig, and is arranged such that respective winding axes for winding the electric wire in each coil winding frame are approximately parallel to each other;

the inserter jig has a pushing-out insertion core for pushing-out the joining pole coil toward the slot of the stator core and inserting this joining pole coil into the slot, and also has plural coil receiving portions arranged on the outer circumferential face of the pushing-out insertion core and respectively receiving each monopole coil from each coil winding frame; and

when the joining pole coil is moved and mounted from the winding jig to the inserter jig, each coil receiving portion is opposed to the tip face of each coil winding frame in the direction of the winding axis, and each coil winding frame and each coil receiving portion are connected to each other, and each of each coil winding frame and each coil receiving portion is constructed so as to form a moving and mounting route for moving and mounting each monopole coil.

In the coil forming insertion device of the invention, the joining pole coil is formed in the above winding jig and each monopole coil is approximately simultaneously and reliably delivered to each coil receiving portion and can be moved and mounted to the inserter jig as the joining pole coil.

Namely, in the above winding jig, the plural coil winding frames are arranged approximately in parallel with each other. In this winding jig, the joining pole coil can be formed by forming the monopole coil in each coil winding frame. Therefore, each monopole coil can be formed in each coil winding frame in which the mutual position relation is fixed. Accordingly, it is possible to stabilize the length of a connecting wire formed between the respective monopole coils wound around the respective coil winding frames.

Further, the above inserter jig has each coil receiving portion opposed to the tip face of each coil winding frame. When each coil winding frame and each coil receiving portion are connected, each coil winding frame and each coil receiving portion can form each moving and mounting route. Therefore, when each monopole coil is delivered from each coil winding frame to each coil receiving portion, each monopole coil can be reliably delivered along each moving and mounting route while each moving and mounting route is maintained within the ring of the monopole coil.

Each monopole coil can be approximately simultaneously

delivered to the coil receiving portion. Therefore, in this delivery, there is almost no case in which the winding order of each electric wire in each monopole coil is different from the winding order in which the above winding operation is performed.

Therefore, this joining pole coil can be moved and mounted from the winding jig to the inserter jig without almost changing the forming state of the joining pole coil.

A third aspect of the invention resides in a coil forming insertion method in which a winding jig for forming a joining pole coil and an inserter jig for inserting and arranging the joining pole coil in a slot formed on the inner circumferential face of a stator core are used,

plural monopole coils are formed and the joining pole coil constructed by joining the plural monopole coils is also formed by winding an electric wire around each of plural coil winding frames arranged in the winding jig, and

each monopole coil held to each coil winding frame is simultaneously delivered to each of plural coil receiving portions arranged in the inserter jig, and the joining pole coil is moved and mounted to the inserter jig.

In the coil forming insertion method of the invention, the joining pole coil is formed in the above winding jig and each monopole coil is approximately simultaneously delivered to each coil receiving portion and can be moved and mounted

to the inserter jig as the joining pole coil.

Therefore, similar to the above invention, the length of the connecting wire connecting the respective monopole coils to each other can be stabilized, and the above moving and mounting operation can be performed without almost changing the forming state of the joining pole coil by approximately simultaneously and reliably delivering each monopole coil to each coil receiving portion.

A fourth aspect of the invention resides in a coil forming insertion method including a coil forming process for forming a joining pole coil constructed by joining plural monopole coils formed by winding an electric wire in a loop shape in a winding jig, a coil moving and mounting process for moving and mounting the joining pole coil from the winding jig to the inserter jig, and a coil insertion process for inserting and arranging the joining pole coil in a slot formed on the inner circumferential face of a stator core from the inserter jig;

wherein, in the coil forming process, plural coil winding frames for forming the monopole coil by winding the electric wire are arranged approximately in a circumferential shape and the joining pole coil is formed by using the winding jig constructed by arranging respective winding axes for winding the electric wire in the respective coil winding frames approximately in parallel with each other, and

in the coil moving and mounting process, the inserter

jig has a pushing-out insertion core for pushing-out the joining pole coil toward the slot of the stator core and inserting the joining pole coil into this slot, and also has plural coil receiving portions arranged on the outer circumferential face of the pushing-out insertion core and respectively receiving each monopole coil from each coil winding frame; each coil receiving portion is opposed to the tip face of each coil winding frame in the direction of the winding axis and each coil winding frame and each coil receiving portion are connected by using the inserter jig; and each of each coil winding frame and each coil receiving portion forms a moving and mounting route for moving and mounting each monopole coil, and each monopole coil is delivered from each coil winding frame to each coil receiving portion while each moving and mounting route is maintained within the ring of each monopole coil.

In the coil forming insertion method of the invention, the joining pole coil is formed by using the above winding jig in the above coil forming process. In the above coil moving and mounting process, each monopole coil is reliably delivered to each coil receiving portion and can be moved and mounted to the inserter jig as the joining pole coil.

Therefore, similar to the above invention, the length of the connecting wire connecting the respective monopole coils to each other can be stabilized, and the above moving and mounting operation can be performed without almost changing the forming

state of the joining pole coil by approximately simultaneously and reliably delivering each monopole coil to each coil receiving portion.

Brief Description of the Drawings

Fig. 1 is a perspective view showing a coil forming device in an embodiment 1.

Fig. 2 is a perspective view showing the coil forming device in a state in which a joining pole coil is formed by forming each monopole coil in each coil winding frame in the embodiment 1.

Fig. 3 is an explanatory view showing each winding frame in a state in which an outside winding frame portion is located in a winding position in the embodiment 1.

Fig. 4 is an explanatory view showing each winding frame in a state in which the outside winding frame portion is located in a separating position in the embodiment 1.

Fig. 5 is a perspective view showing the coil forming device in a state in which the winding axis of a first coil winding frame is approximately conformed to the turning central axis of a turning arm and is projected from all the remaining winding frames in the embodiment 1.

Fig. 6 is a perspective view showing the coil forming device in a state in which the monopole coil is formed by winding an electric wire around the first coil winding frame in the

embodiment 1.

Fig. 7 is a perspective view showing the coil forming device in a state in which the winding axis of a first connecting wire winding frame is approximately conformed to the turning central axis of the turning arm and is projected from all the remaining winding frames and the electric wire is wound around this first connecting wire winding frame in the embodiment 1.

Fig. 8 is a perspective view showing the coil forming device in a state in which the winding axis of a second coil winding frame is approximately conformed to the turning central axis of the turning arm and is projected from all the remaining winding frames in the embodiment 1.

Fig. 9 is a perspective view showing the coil forming device in a state in which the monopole coil is formed by winding the electric wire around the second coil winding frame in the embodiment 1.

Fig. 10 is a perspective view showing the coil forming device in a state in which a joining pole coil is formed by winding the electric wire around all the winding frames in the embodiment 1.

Fig. 11 is an explanatory view typically showing a state in which the joining pole coil is formed by winding the electric wire around all the winding frames in the embodiment 1.

Fig. 12 is an explanatory plan view showing a coil forming insertion device in a state in which the joining pole coil is

moved and mounted from a winding jig to an inserter jig in an embodiment 2.

Fig. 13 is an explanatory view showing the coil forming insertion device in a state in which the winding jig for holding the joining pole coil is advanced to the inserter jig in the embodiment 2.

Fig. 14 is an explanatory view showing the coil forming insertion device in a state in which the tip portion in a coil receiving portion of the inserter jig is fitted into a fitting concave portion in the coil winding frame of the winding jig in the embodiment 2.

Fig. 15 is an explanatory view showing the coil forming insertion device in a state in which each outside winding frame portion in each coil winding frame of the winding jig is moved to the separating position and each monopole coil is separated from each coil winding frame in the embodiment 2.

Fig. 16 is an explanatory view showing the coil forming insertion device in a state in which an expelling core of the winding jig is advanced and the joining pole coil is pushed out until a prescribing position in the inserter jig in the embodiment 2.

Fig. 17 is an explanatory view showing the coil forming insertion device in a state in which the winding jig is retreated from the inserter jig in the embodiment 2.

Fig. 18 is an explanatory view showing the coil forming

insertion device in a state in which each coil receiving portion in the inserter jig is opposed to the inner circumferential face of a stator core in the embodiment 2.

Fig. 19 is an explanatory plan view showing the coil forming insertion device in a state in which each coil receiving portion and each guide portion in the inserter jig are opposed to the inner circumferential face of the stator core in the embodiment 2.

Fig. 20 is an explanatory plan view showing the coil forming insertion device in a state in which the joining pole coil is inserted and arranged in each slot of the stator core from the inserter jig in the embodiment 2.

Best Mode for Carrying Out the Invention

The preferred embodiment modes in the invention mentioned above will be explained.

In the above first and second aspects of the invention, it is preferable that each coil winding frame has a fitting concave portion for fitting the tip portion of each coil receiving portion onto the tip face, and

the joining pole coil is moved and mounted from the winding jig to the inserter jig in a state in which the tip portion of the coil receiving portion is fitted into the fitting concave portion of each coil winding frame.

In this case, each coil winding frame and each coil

receiving portion can be easily and reliably connected to each other by the above fitting, and the above moving and mounting route is easily formed.

Further, it is preferable to form the above fitting concave portion at a depth able to insert and arrange the above coil receiving portion within the entire ring of the monopole coil wound around the above coil winding frame.

In this case, when the above fitting is performed, the tip portion of each coil receiving portion is necessarily inserted and arranged within the ring of each monopole coil in each coil winding frame. Therefore, each monopole coil can be further reliably delivered from each coil winding frame to each coil receiving portion.

It is also preferable that the winding jig has an expelling core arranged so as to be advanced and retreated on the inner circumferential side of each coil winding frame so as to expel the joining pole coil to the inserter jig.

In this case, each monopole coil delivered from each coil winding frame to each coil receiving portion is pushed out by the above expelling core, and can be moved until a predetermined position in the above inserter jig.

It is also preferable that each coil winding frame has an inside winding frame portion arranged on the inner circumferential side as the central point side of the winding jig, and an outside winding frame portion oppositely arranged

on the outer circumferential side of the inside winding frame portion, and

the outside winding frame portion can be moved so as to change the distance between this outside winding frame portion and the inside winding frame portion between a winding position in winding the electric wire and a separating position in separating the monopole coil after the winding operation is performed from the coil winding frame.

In this case, when the above electric wire is wound, the above outside winding frame portion is set to be located in the above winding position in each coil winding frame, and it is possible to form the monopole coil of a winding diameter determined by the distance between the outside winding frame portion and the above inside winding frame portion.

Further, when each coil winding frame is connected to each coil receiving portion, each outside winding frame portion is set to be located in the above separating position in each coil winding frame, and it is possible to separate each monopole coil by reducing the distance between each outside winding frame portion and each inside winding frame portion. Each monopole coil can be further easily delivered from each coil winding frame to each coil receiving portion.

It is also preferable that the outside winding frame portion is stepwise increased in diameter toward the advancing direction on the side opposed to the inserter jig.

In this case, when the above outside winding frame portion is set to be located in the above winding position, the monopole coil having a winding diameter of the electric wire increased toward the above advancing direction can be formed by forming a state in which the outside diameter of the coil winding frame is stepwise increased toward the above advancing direction. Therefore, when the joining pole coil constructed by this monopole coil is inserted and arranged in the slot in a stator core or a rotor core, this joining pole coil can be collectively inserted and arranged by locating the large side of the above winding diameter on the opening side of the slot for inserting and arranging the joining pole coil.

Further, when the above outside winding frame portion is set to be located in the above separating position, each monopole coil can be easily separated by forming a state in which the outside diameter of the coil winding frame is reduced toward the above advancing direction.

It is also preferable that the winding jig has a turning arm arranged so as to be turned with a turning central axis connected to a turning device as a center, and also has an index holder rotatably arranged with respect to the turning arm in a state in which a rotating central axis formed in a position offset approximately in parallel with the turning central axis is set to a center,

the plural coil winding frames are arranged in the index

holder in an arc shape at about the same distance from the rotating central axis, and the respective winding axes for winding the electric wire in the respective coil winding frames are approximately parallel to each other and are also approximately parallel to the turning central axis, and

each coil winding frame is arranged so as to be advanced and retreated in the direction of the turning central axis with respect to the index holder, and the coil winding frame for winding the electric wire is constructed so as to be advanced in the advancing direction on the side opposed to the inserter jig with respect to the remaining coil winding frames and is also constructed so as to be projected from the remaining coil winding frames.

In this case, when the above joining pole coil is formed, the above index holder and the above plural coil winding frames are entirely rotated by the above turning arm in a state in which the coil winding frame for winding the above electric wire is projected from the remaining coil winding frames toward the above advancing direction. The electric wire is wound around the above projected coil winding frame. Therefore, no electric wire is wound while rotating a winder, etc. from the outer circumference of a fixed winding frame as in the conventional case. Accordingly, each monopole coil can be formed in each coil winding frame without almost generating torsion in the electric wire.

Further, each coil winding frame can sequentially approach the above turning central axis from the coil winding frame for winding the above electric wire by rotating the above index holder. Therefore, although the above coil forming device has the above plural coil winding frames to form the above joining pole coil, the above electric wire can be wound in a state in which the coil winding frame for winding the electric wire is not eccentric so much from the above turning central axis.

After the monopole coil is formed in one coil winding frame, the above index holder is moved and the next coil winding frame adjacent to the above one coil winding frame approaches the above turning central axis. Similar to the above case, the monopole coil can be formed.

Therefore, the electric wire can be stably wound without changing the supplying direction of the electric wire to each coil winding frame so much to wind the electric wire around each coil winding frame. Therefore, the monopole coil almost not generated in the above torsion can be stably formed with respect to any coil winding frame, and the joining pole coil almost not generated in the torsion can be stably formed.

Further, the coil winding frame for winding the electric wire is projected and the electric wire can be easily supplied to this projected coil winding frame from the direction perpendicular to its winding axis. Therefore, the electric

wire is easily supplied and is also easily wound around the coil winding frame. Further, it is possible to further easily form the joining pole coil in which the above torsion is almost not generated.

In the above third and fourth aspects of the invention, it is preferable that each monopole coil is delivered from each coil winding frame to each coil receiving portion in a state in which the tip portion of the coil receiving portion is fitted into a fitting concave portion formed on the tip face of each coil winding frame in the coil moving and mounting process.

In this case, each coil winding frame and each coil receiving portion can be easily and reliably connected to each other by the above fitting, and the above moving and mounting route is easily formed and the above delivery can be performed.

It is also preferable that an expelling core arranged on the inner circumferential side of each coil winding frame is advanced in the advancing direction on the side opposed to the inserter jig, and each monopole coil delivered to each coil receiving portion is pushed out until a predetermined position in the inserter jig in the coil moving and mounting process.

In this case, each monopole coil delivered from each coil winding frame to each coil receiving portion is pushed out by the above expelling core, and can be reliably moved until a predetermined position in the above inserter jig. Further, the above predetermined position is set to a prescribing position

in inserting and arranging the joining pole coil from the above inserter jig to the slot of the above stator core. Thus, after the joining pole coil is moved and mounted to the inserter jig, the joining pole coil in this moving and mounting state can be inserted and arranged in the slot of the stator core.

It is also preferable that each monopole coil is separated from each coil winding frame by reducing the outside diameter of each coil winding frame, and each monopole coil is delivered from each coil winding frame to each coil receiving portion in the coil moving and mounting process.

In this case, the outside diameter of each coil winding frame is set to a regular outside diameter and the monopole coil of the regular size is formed in the above coil forming process. In the above coil moving and mounting process, the outside diameter of each coil winding frame is reduced and the above joining pole coil can be easily separated from each coil winding frame. Each monopole coil can be further easily delivered from each coil winding frame to each coil receiving portion.

It is also preferable that, in the coil forming process, the monopole coil having a winding diameter of the electric wire increased toward the advancing direction is formed by forming a state in which the outside diameter of the coil winding frame for winding the electric wire is stepwise increased in the advancing direction on the side opposed to the inserter

jig, and

in the coil moving and mounting process, each monopole coil is separated from each coil winding frame by forming a state in which the outside diameter of each coil winding frame is reduced toward the advancing direction.

In this case, it is possible to easily form the joining pole coil constructed by the monopole coil having a winding diameter of the electric wire increased from one side to the other side. Further, this joining pole coil can be also easily separated.

Embodiments

In the following embodiment 1, a coil forming device and a coil forming method for forming the joining pole coil will be explained by using Figs. 1 to 11, and a coil forming process for forming the joining pole coil from the electric wire will be explained.

Further, in the following embodiment 2, a coil forming insertion device and a coil forming insertion method having the winding jig and the inserter jig will be explained by using Figs. 12 to 20. Further, a coil moving and mounting process for once moving and mounting the joining pole coil held to the winding jig to the inserter jig, and a coil insertion process for inserting and arranging the joining pole coil from the inserter jig in each slot of the stator core will be explained.

Further, the winding jig used in the embodiment 2 is the same as the winding jig used in the embodiment 1, and will be also explained by using one of Figs. 1 to 11 in the embodiment 2 in a certain case.

(Embodiment 1)

As shown in Figs. 1 and 2, the coil forming device 1 of this example forms a joining pole coil 9 as a coil for a motor in which plural monopole coils 90 formed by winding an electric wire 99 in a loop shape are joined. The coil forming device 1 has an unillustrated base frame, a turning arm 21 rotatably arranged in this base frame with a turning central axis C2 connected to an unillustrated turning device as a center, and a winding jig 2. Further, the winding jig 2 has an index holder 22 movably arranged with respect to the turning arm 21, and plural coil winding frames 3 arranged on the outer circumferential face of this index holder 22.

Further, each winding axis C1 for winding the above electric wire 99 in each coil winding frame 3 is mutually approximately parallel and is also approximately parallel to the above turning central axis C2. The coil forming device 1 is constructed such that the coil winding frame 3 for winding the above electric wire 99 can sequentially approach the above turning central axis C2 by moving the above index holder 22.

This construction will next be explained in detail.

As shown in Figs. 1 and 2, the above index holder 22 is

rotatably and movably arranged in the above turning arm 21 by setting a rotating central axis C3 formed in a position approximately offset in parallel with the above turning central axis C2 to a center. Further, each coil winding frame 3 is arranged in the above index holder 22 in an arc shape at about the same distance from the above rotating central axis C3.

The winding frame distance L1 from the above rotating central axis C3 to the winding axis C1 in each coil winding frame 3 is set to about the same as the offset distance L2 from the turning central axis C2 of the above turning arm 21 to the rotating central axis C3 of the above index holder 22.

The winding axis C1 of the coil winding frame 3 for winding the above electric wire 99 can be sequentially approximately conformed to the above turning central axis C2 by rotating the above index holder 22 by a predetermined angle with respect to the turning arm 21, and the electric wire 99 can be wound in this state.

Further, a joining pole coil 9 joined in the arc shape can be formed by each coil winding frame 3 arranged in the above arc shape (see Fig. 11).

As shown in Fig. 3, each coil winding frame 3 is arranged so as to be advanced and retreated in the direction of the above turning central axis C2 with respect to the above index holder 22. The coil winding frame 3 for winding the above electric wire 99 can be projected from the remaining coil winding frames

3 by advancing the coil winding frame 3 in the advancing direction separated from the above turning arm 21 with respect to the remaining coil winding frames 3. Therefore, the electric wire 99 can be easily supplied to the above projected coil winding frame 3 from the direction perpendicular to its winding axis C1. Accordingly, the electric wire 99 is easily supplied and can be easily wound around the coil winding frame 3.

As shown in Fig. 2, each coil winding frame 3 is arranged in a circumferential shape on the outer circumferential face of the above index holder 22. In this example, each coil winding frame 3 is arranged in a radiating shape approximately at an equal interval on the outer circumferential face of the index holder 22. Further, in this example, four coil winding frames 3 are arranged to form the joining pole coil 9 constructed by joining four monopole coils 90.

As shown in Figs. 3 and 4, each coil winding frame 3 has an inside winding frame portion 31 attached to the index holder 22, and an outside winding frame portion 32 arranged so as to be opposed to this inside winding frame portion 31. The outside winding frame portion 32 can be moved so as to change the distance between the outside winding frame portion 32 and the inside winding frame portion 31 between a winding position 301 in winding the above electric wire 99 as shown in Fig. 3 and a separating position 302 in separating the monopole coil 90 from the coil winding frame 3 after the above winding operation is

performed as shown in Fig. 4. Further, the diameter of the outside winding frame portion 32 is stepwise increased toward the advancing direction separated from the above turning arm 21.

As shown in Fig. 3, when the outside winding frame portion 32 is set to be located in the winding position 301, the state in which the outside diameter of the coil winding frame 3 is stepwise increased toward the above advancing direction can be formed. It is possible to form the monopole coil 90 in which the winding diameter of the electric wire 99 is increased toward the advancing direction. It is also possible to form the monopole coil 90 having the winding diameter of a regular size determined by the distance between the outside winding frame portion 32 and the inside winding frame portion 31.

When the joining pole coil 9 constructed by each monopole coil 90 is inserted and arranged in the slot 810 in the stator core 81, the large side of the above winding diameter is located on the opening side of the slot 810 for performing the insertion and arrangement so that this joining pole coil 9 can be inserted and arranged. A coil end portion formed by projecting each monopole coil 90 from both axial end portions of the stator core 81 can be reduced in size by moving and deforming this coil end portion toward the outer direction of the stator core 81 from the portion located on the above opening side. Namely, the length of each monopole coil 90 approaches the length of

a required minimum limit and the coil end portion can be reduced in size by forming each monopole coil 90 having the winding diameter increased from one side to the other side.

As shown in Fig. 4, when the outside winding frame portion 32 is set to be located in the separating position 302, it is possible to form a state in which the outside diameter of the coil winding frame 3 is reduced toward the above advancing direction. Each monopole coil 90 can be easily separated by reducing the distance between the outside winding frame portion 32 and the inside winding frame portion 31.

As shown in Figs. 3 and 4, each coil winding frame 3 is constructed in this example such that a handle 35 is arranged in this coil winding frame 3 and is manually advanced and retreated and the advancing-retreating position is fixed by a positioning pin 34. In addition to this, each coil winding frame 3 can be also advanced and retreated by using a cylinder or a motor, etc.

In this example, a cam 33 is rotatably arranged in each inside winding frame portion 31 in each coil winding frame 3. As shown in Fig. 3, the above winding position 301 is formed when the cam 33 rises toward each outside winding frame portion 32. As shown in Fig. 4, the above separating position 302 is formed when the cam 33 falls toward each inside winding frame portion 31. In addition to this, the outside winding frame portion 32 can be also moved by using a cylinder or a motor,

etc. between the winding position 301 and the separating position 302.

As shown in Figs. 1 and 2, a connecting wire winding frame 41 for winding a connecting wire 995 connecting the respective monopole coils 90 to each other is arranged between the respective coil winding frames 3 in the above index holder 22. In this example, three connecting wire winding frames 41 are arranged between the above four coil winding frames 3. The connecting wire 995 of a prescribed length can be formed between the monopole coils 90 formed in the respective coil winding frames 3 by winding the electric wire 99 around the connecting wire winding frame 41 (see Fig. 11).

As shown in Figs. 1 and 2, in this example, a lead winding frame 42 is arranged between a first coil winding frame 3a for firstly winding the electric wire 99 and a fourth coil winding frame 3d for finally winding the electric wire 99. The lead winding frame 42 is arranged to secure the lead wire 996 of a predetermined length in advance by winding the above electric wire 99 before the electric wire 99 is wound around the first coil winding frame 3a. This lead wire 996 is the electric wire 99 connected to the winding end portion of a first monopole coil 90a formed in the first coil winding frame 3a (see Fig. 11).

In this example, the sectional shape of the lead winding frame 42 is approximately set to a circular shape, and the lead

wire 996 of a predetermined length can be stably secured in the winding end portion of the first monopole coil 90a without generating bending, etc. in the electric wire 99.

Similar to the above coil winding frame 3, the above connecting wire winding frame 41 and the lead winding frame 42 can be also advanced and retreated in the direction of the above turning central axis C2 with respect to the above index holder 22, and are advanced in the advancing direction separated from the above turning arm 21 with respect to the remaining coil winding frames 3 and connecting wire winding frames 41 and can be projected from the remaining coil winding frames 3 and connecting wire winding frames 41.

As shown in Figs. 1 and 2, the above turning arm 21 can be turned in both the normal and reverse rotating directions with the above turning central axis C2 as a center. In this example, the joining pole coil 9 constructed by joining four monopole coils 90 wound in the same winding direction is formed. Therefore, the rotating direction of the turning arm 21 at the winding time around the above coil winding frame 3 is reverse to the rotating direction of the turning arm 21 at the winding time around the above connecting wire winding frame 41. The above coil forming device 1 is alternately rotated in both the normal and reverse rotating directions and forms the above joining pole coil 9.

In the following description, the turning direction of

the turning arm 21 at the winding time around the coil winding frame 3 is called the normal rotating direction, and the turning direction of the turning arm 21 at the winding time around the connecting wire winding frame 41 and the lead winding frame 42 is called the reverse rotating direction.

A turning device for turning the above turning arm 21 with its turning central axis C2 as a center is arranged in the above base frame although this turning device is omitted in the drawings. The turning central axis C2 is connected to the turning device. In this example, the turning device is constructed so as to be manually turned by arranging a handle in the turning arm 21. In addition to this, various kinds of motors or an index cylinder, etc. operated by using an electric operation, oil pressure or air, etc. can be also used as the turning device.

A coil forming process for forming the joining pole coil 9 by using the above coil forming device 1 will next be explained.

In this coil forming process, the monopole coil 90 is formed by sequentially performing an index process, a projecting process and a winding process described below with respect to each coil winding frame 3 by using the above coil forming device 1, and the joining pole coil 9 constructed by joining this monopole coil 90 is formed.

As shown in Fig. 1, in the above coil forming device 1, the above lead winding frame 42 is located in the position closest

to the turning central axis C2 in the above turning arm 21 in the original position of the above index holder 22. In this original position, the winding axis C1 in the lead winding frame 42 is approximately conformed to the turning central axis C2 in the turning arm 21.

As a pretreatment process, the lead winding frame 42 is advanced and is projected as compared with each coil winding frame 3 and each connecting wire winding frame 41. Then, the electric wire 99 is supplied to the above lead winding frame 42 and the turning arm 21 is turned in the reverse rotating direction so that the electric wire 99 is wound around the lead winding frame 42 and the lead wire 996 of a predetermined length is formed.

The above electric wire 99 is supplied from the transversal direction of the above coil forming device 1, i.e., from the direction perpendicular to a winding face for winding the electric wire 99 around each coil winding frame 3, each connecting wire winding frame 41 and the lead winding frame 42.

Next, as shown in Fig. 5, as the above index process, the index holder 22 is rotated by a predetermined angle and the winding axis C1 of the first coil winding frame 3a is approximately conformed to the above turning central axis C2.

Further, as the above projecting process, the first coil winding frame 3a is advanced and projected and the lead winding

frame 42 is retreated.

As shown in Fig. 6, as the above winding process, the electric wire 99 is supplied to the first coil winding frame 3a and the turning arm 21 is turned in the normal rotating direction, and the first monopole coil 90a is formed by winding the electric wire 99 plural times around the first coil winding frame 3a. The outside winding frame portion 32 in the first coil winding frame 3a is located in the above winding position 301, and a state in which the outside diameter of this first coil winding frame 3a is stepwise increased toward the above advancing direction is formed. It is thus possible to form the monopole coil 90 in which the winding diameter of the electric wire 99 is increased toward the advancing direction.

Next, as shown in Fig. 7, the above index process is again performed and the winding axis C1 of a first connecting wire winding frame 41a is approximately conformed to the above turning central axis C2 by rotating the index holder 22 by a predetermined angle. Further, as the projecting process, the first connecting wire winding frame 41a is advanced and projected and the first coil winding frame 3a is retreated.

Next, as the connecting wire forming process, the electric wire 99 is supplied to the first connecting wire winding frame 41a and the turning arm 21 is turned in the reverse rotating direction, and the above connecting wire 995 is formed by winding the electric wire 99 around the first connecting wire winding

frame 41a.

Next, as shown in Fig. 8, the above index process is again performed and the index holder 22 is rotated by a predetermined angle and the winding axis C1 of a second coil winding frame 3b is approximately conformed to the above turning central axis C2. Further, as the projecting process, the second coil winding frame 3b is advanced and projected and the first connecting wire winding frame 41a is retreated.

As shown in Fig. 9, the above winding process is then again performed and the electric wire 99 is supplied to the second coil winding frame 3b and the turning arm 21 is turned in the normal rotating direction and the second monopole coil 90b is formed by winding the electric wire 99 plural times around the second coil winding frame 3b.

Thereafter, as shown in Fig. 10, similar to the above case, each connecting wire 995 is formed by performing the above index process, the projecting process and the connecting wire forming process with respect to a second connecting wire winding frame 41b and a third connecting wire winding frame 41c. A third monopole coil 90c and a fourth monopole coil 90d are formed by performing the above index process, the projecting process and the winding process with respect to a third coil winding frame 3c and a fourth coil winding frame 3d.

As shown in Fig. 11, the joining pole coil 9 constructed by joining the first to fourth monopole coils 90a to 90d by

the above respective connecting wires 995 is formed. This figure is an explanatory view typically showing a state in which the respective monopole coils 90a to 90d are formed in the above first to fourth coil winding frames 3a to 3d and the joining pole coil 9 is formed in the entire respective winding frames 3a to 3d, 41a to 41d, 42.

In the above coil forming device 1, the above electric wire 99 is wound around the coil winding frame 3 closest to the above turning central axis C2 and the above monopole coil 90 is formed by turning the above entire plural coil winding frames 3 by the above turning arm 21.

The electric wire 99 is wound by entirely rotating the plural coil winding frames 3 and the index holder 22 arranged in the above turning arm 21 by turning this turning arm 21. Therefore, no electric wire 99 is wound while rotating a winder, etc. from the outer circumference of the fixed winding frame as in the conventional case. Accordingly, each monopole coil 90 can be formed in each coil winding frame 3 without almost generating distortion in the electric wire 99.

Further, the winding axis C1 of the coil winding frame 3 for winding the above electric wire 99 can be sequentially approximately conformed to the turning central axis C2 of the above turning arm 21 by rotating the above index holder 22. Therefore, although the above coil forming device 1 has the plural coil winding frames 3 to form the joining pole coil 9,

the electric wire 99 can be wound in a state in which the coil winding frame 3 for performing the winding operation is not eccentric so much from the turning central axis C2.

After the monopole coil 90 is formed in one of the coil winding frames 3, the above index holder 22 is rotated and the winding axis C1 of the next coil winding frame 3 adjacent to the above one of the coil winding frames 3 is approximately conformed to the above turning central axis C2, and the monopole coil 90 can be formed similarly to the above case.

Therefore, the above electric wire 99 can be supplied from an approximately constant direction perpendicular to the winding axis C1 of the coil winding frame 3 for performing the winding operation. Thus, the electric wire 99 can be stably wound around each coil winding frame 3. Therefore, the monopole coil 90 almost not generated in the above torsion can be stably formed with respect to any coil winding frame 3. Thus, it is possible to stably form the joining pole coil 9 in which no torsion is almost generated.

(Embodiment 2)

As shown in Fig. 13, a coil forming insertion device 5 of this example has a winding jig 2 and an inserter jig 6. The winding jig 2 forms the joining pole coil 9 constructed by joining plural monopole coils 90 constructed by winding the electric wire 99 in a loop shape. The inserter jig 6 is opposed to this

winding jig 2 and receives the above joining pole coil 9 and inserts and arranges this joining pole coil 9 in plural slots 810 formed on the inner circumferential face of the stator core 81.

As shown in Fig. 12, the above winding jig 2 has plural coil winding frames 3 and the above inserter jig 6 has plural coil receiving portions 62 for respectively receiving the above respective monopole coils 90 from the above respective coil winding frames 3.

As shown in Fig. 16, the coil forming insertion device 5 is constructed such that each coil receiving portion 62 is opposed to each coil winding frame 3, and the joining pole coil 9 constructed by joining each monopole coil 90 wound around each coil winding frame 3 is moved and mounted from the winding jig 2 to the inserter jig 6.

This construction will next be explained in detail.

As shown in Figs. 1 and 2, in the above winding jig 2, the plural coil winding frames 3 for forming the above monopole coil 90 by winding the above electric wire 99 are arranged at about the same distance from the central point of the winding jig 2. Further, in the winding jig 2, the respective winding axes C1 for winding the above electric wire 99 in the respective coil winding frames 3 are approximately parallel to each other.

On the other hand, as shown in Figs. 12 and 13, the above inserter jig 6 has a pushing-out insertion core 61 for

pushing-out the above joining pole coil 9 toward the above slot 810 of the above stator core 81 and inserting this joining pole coil 9 into this slot 810. The above plural coil receiving portions 62 are arranged on the outer circumferential face of the pushing-out insertion core 61 and respectively receive each monopole coil 90 from each coil winding frame 3.

The coil forming insertion device 5 is constructed as shown in Figs. 12 and 14. Namely, when the above joining pole coil 9 is moved and mounted from the above winding jig 2 to the above inserter jig 6, each coil receiving portion 62 is opposed to the tip face 311 of each coil winding frame 3 in the direction of the above winding axis C1, and each coil winding frame 3 and each coil receiving portion 62 are connected to each other, and each of each coil winding frame 3 and each coil receiving portion 62 forms a moving mounting route 60 for moving and mounting each monopole coil 90.

As shown in Figs. 3 and 12, each coil winding frame 3 has a fitting concave portion 312 for fitting the tip portion 621 of each coil receiving portion 62 in the above inserter jig 6 on the above tip face 311 of the coil winding frame 3. In this example, this fitting concave portion 312 is formed on the tip face 311 of each inside winding frame portion 31 of each coil winding frame 3.

As shown in Fig. 14, this fitting concave portion 312 is formed at a depth able to insert and arrange the coil receiving

portion 62 within the entire ring of the monopole coil 90 wound around the coil winding frame 3. Namely, the fitting concave portion 312 is deeply formed from the tip face 311 of each coil winding frame 3 in comparison with the winding depth from the tip face 311 of each coil winding frame 3 to the position for winding the above electric wire 99.

As shown in Figs. 12 and 14, each coil winding frame 3 and each coil receiving portion 62 can be connected by fitting the tip portion 621 of each coil receiving portion 62 into the fitting concave portion 312 of each coil winding frame 3. Further, the joining pole coil 9 can be moved and mounted from the winding jig 2 to the inserter jig 6 in this fitting state.

When this fitting is performed, the tip portion 621 of each coil receiving portion 62 is necessarily inserted and arranged within the ring of each monopole coil 90 in each coil winding frame 3.

As shown in Figs. 12 and 13, the above winding jig 2 has an expelling core 23 arranged so as to be advanced and retreated on the inner circumferential side of each coil winding frame 3 to expel the above joining pole coil 9 to the above inserter jig 6. As shown in Fig. 16, this expelling core 23 can push-out each monopole coil 90 delivered to each coil receiving portion 62 until a predetermined position in the inserter jig 6 by advancing the expelling core 23 in the advancing direction (the advancing direction separated from the above turning arm 21)

on the side opposed to the above inserter jig 6.

In this example, as shown in Fig. 18, the above predetermined position is set to a prescribing position when the joining pole coil 9 is inserted and arranged from the inserter jig 6 to the slot 810 of the above stator core 81. Therefore, after the joining pole coil 9 is moved and mounted to the inserter jig 6, the joining pole coil 9 in this moving and mounting state can be inserted and arranged in the slot 810 of the stator core 81.

As shown in Fig. 12, the above inserter jig 6 has plural guide portions 63 arranged toward about the same direction as the forming direction of the coil receiving portion 62 between the respective coil receiving portions 62. As shown in Fig. 19, this guide portion 63 is opposed to teeth 811 located between the respective slots 810 of the above stator core 81 and guides the insertion and arrangement of the above joining pole coil 9 into each slot 810.

As shown in Fig. 12, an insertion clearance 64 able to insert the electric wire 99 in the monopole coil 90 is formed between each guide portion 63 and each coil receiving portion 62 adjacent to both sides of this guide portion 63. When the electric wire 99 in each monopole coil 90 is inserted into the above insertion clearance 64 and is inserted and arranged in each coil receiving portion 62, each monopole coil 90 is constructed so as to mix this electric wire 99 with the electric

wire 99 in the adjacent monopole coil 90. Thus, the electric wire 99 in each monopole coil 90 can be reliably inserted and arranged in the slot 810 of each stator core 81.

As shown in Fig. 20, each pushing-out insertion core 61 can be advanced and retreated with respect to each coil receiving portion 62. When each coil receiving portion 62 and each guide portion 63 are opposed to the inner circumferential side of the stator core 81, the monopole coil 90 held to each coil receiving portion 62 can be inserted and arranged in each slot 810 by advancing the pushing-out insertion core 61 toward the stator core 81.

A coil forming insertion method for performing a coil moving and mounting process and a coil insertion process will next be explained. In the coil moving and mounting process, the joining pole coil 9 formed by performing the coil forming process shown in the above embodiment 1 is once moved and mounted to the inserter jig 6. In the coil insertion process, this joining pole coil 9 is inserted and arranged in each slot 810 of the stator core 81 from the inserter jig 6.

In this example, the coil forming process is similar to that in the above embodiment 1.

Next, the coil moving and mounting process for moving and mounting the joining pole coil 9 formed by performing the coil forming process from the above winding jig 2 to the above inserter jig 6 will be explained.

As shown in Fig. 12, in this coil moving and mounting process, the above joining pole coil 9 is moved and mounted from the winding jig 2 to the inserter jig 6 by using the coil forming insertion device 5 having the above winding jig 2 and the inserter jig 6.

Namely, as shown in Fig. 13, in the coil moving and mounting process, the entire winding jig 2 forming the above joining pole coil 9 is first advanced toward the above inserter jig 6. At this time, in each coil winding frame 3 in the winding jig 2, each outside winding frame portion 32 is located in the above winding position 301, and tension is applied to each monopole coil 90. Each monopole coil 90 is maintained so as not to break the state after the above winding operation is performed.

As shown in Fig. 14, the tip portion 621 in each coil receiving portion 62 of the inserter jig 6 is fitted into the fitting concave portion 312 in each coil winding frame 3 of the winding jig 2. Each coil winding frame 3 and each coil receiving portion 62 are connected by this fitting, and each moving and mounting route 60 for moving and mounting each monopole coil 90 is formed by each coil winding frame 3 and each coil receiving portion 62.

At the above fitting time, the tip portion 621 of each coil receiving portion 62 is inserted and arranged within the entire ring of each monopole coil 90 in each coil winding frame

3.

Next, as shown in Fig. 15, each outside winding frame portion 32 in each coil winding frame 3 is moved to the above separating position 302 as the separating process. At this time, the outside diameter of each coil winding frame 3 is shortened by forming a state in which this outside diameter is reduced toward the above advancing direction. Therefore, each monopole coil 90 is separated from each coil winding frame 3.

Next, as shown in Fig. 16, the expelling core 23 of the winding jig 2 is advanced toward the direction of the inserter jig 6. At this time, each monopole coil 90 wound around the outer circumference of each coil winding frame 3 is pushed out until the above prescribing position abutting on the pushing-out insertion core 61 of the inserter jig 6.

At this time, while each moving and mounting route 60 is maintained within the ring of each monopole coil 90, each monopole coil 90 can be delivered from each coil winding frame 3 to each coil receiving portion 62.

Thereafter, as shown in Fig. 17, the winding jig 2 is retreated in the retreating direction separated from the inserter jig 6, and the joining pole coil 9 constructed by joining each monopole coil 90 is completely moved and mounted to the inserter jig 6.

The coil insertion process will next be explained.

As shown in Figs. 18 to 20, in this coil insertion process, the joining pole coil 9 held to the above inserter jig 6 is inserted and arranged in the plural slots 810 formed on the inner circumferential face of the stator core 81.

Namely, as shown in Figs. 18 and 19, each coil receiving portion 62 of the inserter jig 6 is first oppositely arranged on the inner circumferential face side of the stator core 81 in the coil insertion process. At this time, the above respective guide portions 63 are oppositely arranged in the respective teeth 811 between the respective slots 810 on the inner circumferential face of the stator core 81.

Next, as shown in Fig. 20, the above pushing-out insertion core 61 is advanced toward the above stator core 81. At this time, the electric wire 99 in each monopole coil 90 held to each coil receiving portion 62 is inserted and arranged in each slot 810. When the tip of the pushing-out insertion core 61 then exceeds the tip of each coil receiving portion 62 and is advanced, each monopole coil 90 is inserted and arranged within each slot 810, and the joining pole coil 9 can be assembled into the stator core 81.

Thus, the stator in a three-phase motor constructed by U-phase, V-phase and W-phase has been manufactured by executing the above embodiments 1 and 2. In this example, the winding jig 2 is set to have four coil winding frames 3 and three connecting wire winding frames 41, and the inserter jig 6 is set to have

eight coil receiving portions 62 and eight guide portions 63.

A four-pole coil as the joining pole coil 9 constructed by joining four monopole coils 90 is formed in the winding jig 2, and are moved and mounted to the inserter jig 6 twice. The two four-pole coils are assembled into the stator core 81 from the inserter jig 6, and the U-phase constructed by an eight-pole coil is formed by joining the two four-pole coils. With respect to the V-phase and the W-phase, a structure constructed by the eight-pole coil is similarly formed by joining two four-pole coils by performing the above assembly.

In the above coil forming insertion device 5, the joining pole coil 9 is formed in the above winding jig 2, and each monopole coil 90 is reliably delivered to each coil receiving portion 62, and can be moved and mounted to the inserter jig 6 as the joining pole coil 9.

Namely, the plural coil winding frames 3 are arranged in the above winding jig 2, and the joining pole coil 9 can be formed by forming the monopole coil 90 in each coil winding frame 3 in this winding jig 2. Therefore, each monopole coil 90 can be formed in each coil winding frame 3 in which the mutual position relation is fixed, and it is possible to stabilize the length of the connecting wire 995 formed between the monopole coils 90 wound around each coil winding frame 3.

Further, the above inserter jig 6 has each coil receiving portion 62 in which the tip portion 621 is fitted to the fitting

concave portion 312 of each coil winding frame 3. When each coil winding frame 3 and each coil receiving portion 62 are connected to each other, each coil winding frame 3 and each coil receiving portion 62 can form each moving and mounting route 60. Therefore, when each monopole coil 90 is delivered from each coil winding frame 3 to each coil receiving portion 62, each monopole coil 90 can be reliably delivered along each moving and mounting route 60 while maintaining each moving and mounting route 60 within the ring of the monopole coil 90.

Each monopole coil 90 can be approximately simultaneously delivered to the coil receiving portion 62. Therefore, in this delivery, there is almost no case in which the winding order of each electric wire 99 in each monopole coil 90 is different from the winding order in which the above winding operation is performed. Namely, when each monopole coil 90 having the winding diameter increased from the above one side to the other side is moved and mounted to the above inserter jig 6, its winding order is not changed and the monopole coil 90 can be moved and mounted in a state in which each electric wire 99 is aligned.

Therefore, this joining pole coil 9 can be moved and mounted from the winding jig 2 to the inserter jig 6 without almost changing the forming state of the joining pole coil 9.